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Project Summary

Guidance for Landfilling Waste in Economically Developing Countries

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The report offers guidance on all aspects of the planning, design, and implementation of landfills in economically developing countries. The intended audience includes municipal officials, solid waste managers, engineers, and planners.

The report's 18 chapters include critical technical areas such as siting, design, and operation of landfills. Equally important non-technical aspects such as social, economic, and institutional topics relevant to developing landfills in economically developing countries also are discussed.

The guiding principle of the report is the application of acceptable landfill practices within the conditions and availability of resources prevailing in both large urban cities and small communities in economically developing countries.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Preface

The final draft of the report was prepared through the cooperation of several organizations and individuals. It is based on a report prepared several years ago by CalRecovery, Inc., under contract to The World Bank. This report contains substantial modifications to chapters of the former report: it covers additional topics and reflects the content of course materials used by the International Solid Waste Association's (ISWA's) Working Group on Sanitary Landfilling (WGSL) in economically developing countries between 1993 and 1996 on the topic, Landfilling of Wastes. It is expected that the report will be evolving, benefiting from modifications of content based on the results of courses given throughout the world.

Funding for the report was provided through the Environmental Technology Initiative and administered by the U.S. Environmental Protection Agency (EPA), as part of its U.S. Technology for International Environmental Solutions (U.S. TIES). U.S. TIES is an innovative EPA program designed to promote the application of U.S. technology in solving environmental problems worldwide. Additionally, in-kind services were provided by members of ISWA's WGSL and CalRecovery, Inc.

The draft report was peer reviewed by WGSL members Robert Ham (chairman), David J. V. Campbell, Isabelle Paris, and Rainer Stegmann. Additionally, it was reviewed by Susan A. Thorneloe, Allen J. Geswein, Paul F. Cassidy, and David A. Carson of the EPA; Lars M. Johannessen and Carl R. Bartone of the World Bank; and Forbes R. McDougall of Procter & Gamble.

Although the report was funded by the EPA, its contents do not represent EPA regulations and policies. Rather, the contents reflect the authors' analyses and judgements concerning appropriate methods, procedures, and topics relevant to land disposal of solid wastes in economically developing countries. The conditions

relevant to solid waste management in economically developing countries are substantially different than those of industrialized countries.

CalRecovery, Inc. prepared most of the report, under subcontract to Roy F. Weston, Inc. Weston contributed portions of the document, including topics related to design, operation, and environmental monitoring.

Introduction

At present, the adoption and practice of landfilling in many municipalities in economically developing countries are impeded by the lack of reliable and practical information such as that compiled in a guidance document specific to economically developing countries. This report makes every effort to fulfill this need by including, under one cover, explanations and descriptions of technologies and procedures proven appropriate in practice. Within the report are summary explanations of underlying principles, as well as clear and concise guidance for putting the technologies into practice.

Currently, the few available documents on landfilling in many economically developing countries are based on technologies and practices suited only to conditions in, and to the requirements of, industrialized nations. However, technologies and practices suited to industrialized nations rarely can be successfully transferred to economically developing countries without having been adapted to local conditions. The report presents methods for planning and implementing landfills. The methods that are discussed span the spectrum of landfill practice from complex engineered systems (designed for virtually complete control and containment of impacts on human health and safety) to less complex systems that can be afforded particularly by small communities in economically developing countries while promoting acceptable control of the impacts of land disposal of wastes.

The report presents suggestions for review and evaluation, often based on best engineering judgement. The guidance is intended to be of sufficient breadth and generality to cover the wide range of conditions (technical, regulatory, social, economic, and institutional) that exist in economically developing countries, and not necessarily to provide rigid rules to be applied in all circumstances. While the report is written primarily for engineers, planners, and operating staff, it should also be useful to management and high-level public officials for the purposes of planning and budgeting. Municipal officials, by virtue of a review of this report, can gain an awareness of the issues and complexities of landfilling and the importance of these facilities to managing solid waste in a manner that protects the public and the environment. The report will assist users in arriving at decisions in a logical, well-defined, and well-documented manner. Tables, sketches, and drawings are used liberally in order to convey important concepts to the reader. Since this is a guidance document (not an engineering design document), comprehensive and detailed engineering design and analysis are used only where they are the only manner of conveying an important concept. References are cited in each chapter, and a list of other pertinent publications is included at the end of the report in an appendix.

The Guidance Document

The report discusses, in 18 chapters, the principal aspects of planning, constructing, and operating a landfill. The emphasis is on conditions, technologies, and practices that exist in economically developing countries. However, the coverage is sufficiently broad to accommodate the levels of industrialization found in the metropolitan areas of economically developing countries. The range of conditions covered in this report will provide for minimum acceptable disposal standards. As urban income grows and cities urbanize, operational capacity and budgets of sanitation departments may increase sufficiently to permit the imposition of more stringent design and operating standards on waste disposal.

The report begins with an introduction which establishes the need for such a report and discusses the report's objectives and scope. The fundamental principles of landfilling are presented in Chapter 2, including definitions of wastes generated, diverted, and disposed of. Brief general discussions of the methods of landfilling, closure of a dump, and the role of scavengers also are presented. Chapter 3 indicates that any strategy associated with solid waste management cannot be implemented without the support of a legislative framework. As such, the chapter provides brief descriptions of either current or draft legislation for some countries. The discussions are not intended to cover all countries, but are meant to be only examples of the status of legislation associated with solid waste management in both industrialized and economically developing countries.

Waste characterization is covered in Chapter 4. The chapter provides the rationale for having a good understanding of the types, quantity, and characteristics of the residues to be taken to landfills. In addition, the chapter discusses acceptable and unacceptable wastes as well as special wastes. General guidelines are provided for the identification of wastes representing potential risks and hazards when received at landfills. The material includes discussions of other wastes (e.g., industrial, volatile and flammable, bulky and construction and demolition debris, animal manure, and animal carcasses). General methodologies are provided for determining the quantity, composition, and other properties of the residues (e.g., moisture content and bulk density).

The report covers the impacts of waste diversion on landfills in Chapter 5. Waste diversion programs (i.e., programs that reduce the quantities and types of materials discarded for final disposal) play important roles in modern solid waste management strategies. In the chapter, examples are provided of the composition of various types of wastes as well as of the impact of different levels of diversion on the concentration of lead entering a landfill. Finally, an example is provided of the estimation of landfill gas production based on the ultimate analysis of solid waste.

Chapter 6 discusses both non-geological and geological aspects of selecting a site for landfilling. The non-geological aspects include definition of need, types of wastes to be accepted, environmental assessment, and public participation. The geological aspects deal with types of rock, climate, hydrology of the area, risks of water contamination, and a procedure for conducting a geological/hydrogeological study. At the end of the chapter, a proposed classification system for site selection is presented.

Chapter 7 presents an overview and discussion of the various support facilities, or infrastructure, that should be considered during the planning of a landfill operation. Infrastructure includes access roads, drainage, scales, utilities, fencing, and other support facilities.

All important aspects associated with the design and construction of a landfill are discussed in Chapter 8. The topics include general design criteria, types of landfill, contouring, covers, leachate and gas management, closure, and post-closure.

The construction and operation of a landfill require the use of various types of equipment. Chapter 9 discusses spare equipment, multi-purpose equipment, and

maintenance and repair of equipment. In addition, the report reflects the reality that the availability of equipment may be limited in many cases and may have to be borrowed in order to build and operate a landfill.

Chapter 10 deals with the operation of a landfill. The chapter is divided into three parts: general procedures, specific operational procedures, and performance monitoring. The chapter also discusses methods and equipment for monitoring the environmental impacts of a landfill.

The various processes that take place within a landfill are covered in Chapter 11, including physical, chemical, and biological. In addition, discussions are provided on in-place density and settlement.

Leachate formation and water balance receive considerable attention in Chapter 12. Specifically, the chapter provides a procedure for performing a water balance. In addition, Chapter 12 covers leachate migration and the characteristics of leachate.

The chapter on leachate formation is rationally followed by one covering leachate collection and management systems (Chapter 13). The chapter also covers a variety of methods for treating the leachate, such as evaporation and recirculation.

Chapter 14 covers the key aspects associated with the extraction and utilization of landfill gas, including gas production and quality (characteristics), safety aspects, design of extraction systems, and use of the gas. A brief description of the number and type of landfill gas projects throughout the world is provided.

Several aspects associated with resource recovery and utilization are presented in Chapter 15. The discussion addresses both manual and mechanical recovery of secondary materials and includes a comprehensive analysis of scavenging.

Chapter 16 covers an important nontechnical aspect of landfill operation, management and record keeping. The chapter discusses management responsibilities, performance monitoring, and environmental monitoring.

Closure, post-closure, and corrective action are discussed in Chapter 17. Specifically, the chapter discusses the processes for preparing closure and post-closure plans, costs associated with closure and post-closure, issues associated with using the site upon completion of landfilling activities, closure of open dump sites, and landfill mining and reclamation.

The final chapter (Chapter 18) discusses economic considerations associated with landfilling. Topics presented in the chapter include potential methods for cost reduction, capital and operating costs (including sample worksheets for estimating landfill costs), and costs associated with equipment.

Each chapter is accompanied by references. In addition, for readers interested in obtaining more information than that offered in the report, references are provided in an appendix.

Acknowledgments

A number of institutions and individuals made substantial contributions to this report; it would be difficult to list each contributor. Among the institutions that contributed to the preparation of the report, three stand out: EPA, ISWA (in particular the Working Group on Sanitary Landfilling), and The World Bank. Individuals contributing to the review of the report include Susan A. Thorneloe, Allen Geswein, Paul Cassidy, and David Carson (EPA), and David J. V. Campbell, Isabelle Paris, and Rainer Stegmann (WGSL). In addition, the authors are indebted to Professor Robert K. Ham of the University of Wisconsin, who spent countless hours reviewing the report.

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***Susan A. Thorneloe** is the EPA Project Officer (see below).*
The complete report, entitled "Guidance for Landfilling Waste in Economically Developing Countries," (Order No. PB98-142102; Cost: $67.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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